Book Review: Stochastic Modeling: Theory and Reality from an Actuarial Perspective, International Actuarial Association [1]

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For decades, actuaries have historically used statistical and financial models that were inherently considered deterministic in the sense that random fluctuations are often ignored, although some type of sensitivity of the parameter and model assumptions have been employed to have a sense of the possible variation in the results. Today, such sensitivity analysis is unacceptably appropriate when reality is becoming more complex with increasing uncertainty. There is an undeniable need for risk analysis, the primary task of an actuary, to better reflect reality by adopting stochastic modeling. With today's availability and convenience of advanced computing architecture, there is no excuse for actuaries in practice to avoid the use of stochastic methods.

It is the objective of this book to introduce and encourage practicing actuaries to consider stochastic models in their analytical work. The book is a proud initiative of the International Actuarial Association, a global association of actuarial professional organizations, whose aim is to promote the increasing role of actuaries in the measurement and management of risks and uncertainty and simultaneously, to develop professionalism and education standards for its member organizations. The conduct of research is an equally important part of its mission. Written by several life and non-life actuarial experts, the book displays an excellent exposition of various general approaches for stochastic modeling together with the implementation of these approaches to situations specifically suitable for several work of the practicing actuary. It is intended for practicing actuaries in life, non-life and even non-traditional areas of work, from anywhere in the globe by avoiding discussion of practices that may be peculiar to a specific country or region. However, there are certain aspects of pricing, financial reporting and regulation that are unavoidably regional in nature; henceforth, the book has in Appendix B that describes several of these regional and country-specific differences.

This 418-page book is indeed admirably organized and covers both traditional and contemporary approaches to stochastic modeling for actuaries. It is broadly divided into four major sections: Section I covers a catalogue of general methodologies considered stochastic models, Section II aims to provide applications of these methods to broad areas of finance and insurance, Section III explains how to evaluate, interpret and communicate the results, and finally, Section IV, what I believe to be the main appeal of the book, provides seven different case studies. These case studies encompass various relevant actuarial work that ranges from management of annuity products to the calculation of economic capital for a multi-line insurance company.

Section I makes it clear what constitutes a stochastic model: it should be able to capture the random outcomes of the inputs into the model to give a better perspective of the spread and

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distribution of the resulting process being modeled. To illustrate for example, in life insurance, actuaries are typically interested in the present value of a loss-at-issue random variable. Clearly the timing of the payment is never known in advance with certainty, so that this present value has a probability distribution. The historical approach is to calculate the expectation of this present value, called the actuarial present value, and in order to have some sense of the variation, a variance may also be calculated. Sometimes, to understand the probability distribution, a Normal approximation is applied even if unreasonably appropriate. Monte Carlo simulation, one of the general methodologies discussed in this section, is more suitable even in such simple cases. Simulation does not always lead to an exact solution and hence is subject to some error. To tighten this simulation error, some variance reduction techniques such as the use of antithetic and control variates, are offered. When the procedure has to be applied in order to perform projections into the future, the notion of nested stochastic projections is discussed; such projections are increasingly becoming important in situations where principle-based accounting for capital requirements is becoming the norm.

Other meaningful statistical summary measures, apart from mean and variance, are also discussed in the section. The use of a risk measure to better quantify the degree of riskiness of a portfolio of risks, for example, is examined and explained. Risk measures are more meaningful especially in situations where the resulting outcome is expectedly skewed in distribution. Although the notion of risk aversion for quantifying risks is not explicitly accounted for in the calculations, it is implicitly considered through the use of deflators when calculating the expected present value of future cash flows and through the use of other families of risk measures which introduce probability distortion. These methods are often useful for calculating market-consistent values of insurance liabilities or fair values of derivative instruments. Furthermore, the notion of a copula model and how to simulate for some known families of copulas are introduced. Copulas are useful to address the concept of dependencies of risks, which are now becoming an integral part of actuarial management, and albeit short in its description, the section recognizes the importance of being able to capture dependencies beyond linear correlations.

Equally important to point out is the discussion in the early part of Section I of when to use and when not to use stochastic models. Accordingly, the use of stochastic models may be unjustified in situations when it becomes difficult or impossible to: (a) determine the appropriate probability distribution, (b) calibrate the model, or (c) validate the model. In my view, because uncertainty is almost always existent, the practicing actuary should not hesitate to attempt every effort, even more so in difficult or impossible situations, to employ stochastic models because these are the times when they are most needed. For example, as pointed out in the section, when "credible, observable data" is less available, the use of suitable substitute information may be adopted.

Section II provides for some general applications of Section I to some specific situations in financial projections, life and health insurance and non-life insurance. In financial projections, the primary input is usually a set of useful economic scenarios. Using simulation tools, the section offers a comprehensive treatment of generating interest rates for bonds and equities, foreign exchange rates, inflation rates, and default rates suitable for credit risks. In life and health insurance, section II.B offers some useful insights to the modeling of possible catastrophic events which could have astounding financial consequences. Appropriately, the use of a baseline model is the first step and subsequently the combination of this with models that account for the potential of a disease pandemic (e.g. the outbreak of SARS in Hong Kong in 2003) and the potential threat of terrorist attack should follow. Similar approaches can be applied when a dynamic policyholder behavior is needed as input to pricing or reserving for life insurance and annuity products. In non-life insurance, models to predict claims are needed using either the individual or the collective risk model. The usual practice of modeling the frequency (claim count) and severity (claim amount) distributions is to properly calibrate from experience data. To accommodate for the presence of possible explanatory variables to the model, the section advocates for the usefulness of a Generalized Linear Model (GLM) framework. GLM covers a large family of distributions, called the Exponential family, that conveniently include both discrete and continuous distributions making it appropriate for modeling both claim count and claim amount observable data. Despite the enormous flexibility of GLM, the section provides for a short discussion of its limitations. Certainly, there is the possibility of a model misspecification particularly for claims of insurances considered long-tailed for which GLM may be unable to capture. Section II.C.3 offers some insights into the need for catastrophic modeling, just as in life and health insurance. In non-life insurance, catastrophes may come in the form of natural disasters (e.g. earthquake, hurricane, flood) or man-made disasters (e.g. the threat of terrorism).

Section III is largely devoted to the evaluation and discussion of the model results. Despite being a short section, it cannot be substantially underestimated. Issues characteristically raised here are questions of how reasonable the model reflect the historical experience and equally important, the current and future environment. Techniques for model validation is essential in these situations. Because of the complexity of the model and the steps to derive the model, it is recommended that the process be evaluated and reviewed by peers or colleagues. Finally, the results produced by a stochastic model must be well-summarized and communicated. Typically, the audience is not as well-versed with statistical methods, analysis and even the language, so that the type of output produced must be comprehensibly clear.

Finally, Section IV is the most interesting part of the book as it offers seven case studies as concrete illustrations of the many possible applications of stochastic modeling. It starts with a discussion of the development and management of a variable annuity product. As inputs to the stochastic model, the actuary should have a clear understanding of the product design and features (e.g. embedded guarantees) together with the various sources of revenue, including the fee structure, as well as potential expenses. For such a product, there is need for setting up the assumptions for returns of different types of equities together with the dynamic nature of policyholder behavior in terms of forecasting lapses. Hedging the liabilities arising from product guarantees is a relevant addition to the complexity of both the modeling process and the subsequent need for management.

Several other case studies involved the calculation of economic capital for a multi-line life insurance company and a multi-line non-life insurance company, and the process of aggregating the economic capital from both types of companies. Determining the suitable level of capital to ensure company solvency is a very important risk management exercise. While the specifics may be different for life and non-life insurance companies, the general procedure is similarly applicable to both: determining the risk metric, a target level of confidence, a time horizon, and various projection techniques.

In summary, the book will help open awareness to practicing actuaries of the need to construct and develop stochastic models in their respective actuarial work. While the theory and practical techniques offered are widely scattered in the actuarial, finance, statistics, and insurance literature, the book offers a variety of illustrations and case studies to demonstrate its usefulness. At the same time, several aspects of the modeling procedures may differ depending on the purpose of the actuarial valuation. Assumptions can also vary widely between life, health, and non-life insurance products, as well as between countries or regions. This book is an excellent source for the practicing actuary who may wish to incorporate stochastic methods in its work. The authors should be commended for a job well done.